LIFE HISTORY AND ANNUAL PRODUCTION OF A NET-SPINNING CADDISFLY *AOTEAPSYCHE COLONICA* (TRICHOPTERA: HYDROPSYCHIDAE) IN AN UNSTABLE NEW ZEALAND RIVER

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ABSTRACT

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The life history and production of *Aoteapsyche colonica* (Trichoptera: Hydropsychidae) were studied over a 12 month period in a flood-prone river in the South Island of New Zealand. Mean larval density was highest in June (2767 m^2) following a long period (> 6 months) of stable, low flow (< 30 m^3s^{-1}), and lowest in December (30 m^2) following three floods (44 to 79 m^3s^{-1}). Analysis of size-frequency distributions indicated four overlapping groups representing four larval instars (II-V); first instar larvae were not taken in benthic samples. Second instar larvae appeared in October and grew rapidly over summer (November to March). Final instar larvae and pupae were present in all months, but most were collected from October to December indicating that *Aoteapsyche colonica* are univoltine. Annual production was low (3.13 g DW m^2) despite the high larval densities following a long period of stable flow. Mean biomass was 0.61g DW m^2 and production to biomass ratio was 5.13.

KEYWORDS: *Aoteapsyche colonica* - Trichoptera - Hydropsychidae - annual production - life history - floods - disturbance - New Zealand.

INTRODUCTION

Larvae of the hydropsychid caddisfly *Aoteapsyche colonica* (McLachlan) are common in fast flowing streams and rivers throughout New Zealand (Winterbourn & Gregson 1989) and can play an important role in energy transfer within lotic systems. They are generalist feeders ingesting fine particulate organic material, algae; aquatic insects and in turn are preyed upon by other aquatic insects (Winterbourn 1974, Devonport & Winterbourn 1976), fishes (Sagar & Eldon 1983, Scrimgeour & Winterbourn 1987) and birds (Pierce 1986, Collier & Lyon 1991).

A. colonica is particularly abundant in braided rivers on the east coast of the South Island, New Zealand and has been found to comprise up to 21% of the fauna in any one month (Pierce 1986, Sagar 1986, Scrimgeour & Winterbourn 1989). Discharge in these rivers is highly variable and spates that occur throughout the year, frequently exceed 30 m^3s^{-1} the threshold above which gravels and cobbles are mobilized (Scrimgeour & Winterbourn 1989). Numerous studies have shown that floods reduce invertebrate density, biomass and species composition (Hoopes 1974, Fisher *et al*. 1982, Molles 1985), but few studies have included calculations of secondary production in flood-prone rivers and streams (but see Jackson & Fisher 1986).

Although production of *A. colonica* (formerly *Hydropsyche colonica*) has been estimated in two small, stable North Island streams (Hopkins 1976), no study has quantified production in a moderately large, flood prone, New Zealand river. I therefore investigated life history and production of *A. colonica* in the flood prone Ashley River in North Canterbury. Caddisfly density, cohort

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growth, production (P), biomass (B) and turnover rates (P/B) were calculated over a 12 month period.

STUDY AREA

Field work was carried out in the Ashley River (catchment area 1340 km^2), an unstable, braided river, 25 km north of Christchurch, South Island, New Zealand. Mean annual discharge at Ashley Gorge (43°14'S, 172°13'E) 35 km upstream of the study area between 1970 and 1980 was 15.3 $m^{-3}s^{-1}$, but discharge is highly variable (range in flow 1.4 to 462 $m^{-3}s^{-1}$ 1985 to 1987) and frequently exceeds the 30 $m^{-3}s^{-1}$ substrate movement threshold (Bowden 1982).

The study site was located 26 km from the sea, where flood plain width is 500 m, stream bed gradient is less than 5° and the river consisted of up to 6 braids and numerous islets. Substratum consisted mainly of gravels (maximum widths 8 to 65 mm), and small and large cobbles (65 to 90 mm). Water temperatures ranged from 6.5°C in winter (July) to 21.5°C in summer (February). The riparian vegetation is primarily grasses (*Poa* spp.), and willow (*Salix* spp.), with some poplars (*Populus* spp.) and broom (*Cytisus scoparius* L.). Rooted macrophytes were absent from the major channels, but a thin film (mean monthly biomass = 0.03 to 0.15 mg cm^{-2} carbon) of diatoms, mainly *Gomphonema* covered stone surfaces during most months.

Torrentfish (*Cheimarrichthys fosteri* Haast), bluegilled bully (*Gobiomorphus hubbsi* Stokell), longfinned eels (*Anguilla dieffenbachii* Gray), upland bully (*Gobiomorphus breviceps* Stokell) and common river galaxias (*Galaxias vulgaris* Stokell), are the most abundant riffle-dwelling fish species there (Glova *et al.* 1985). A detailed description of the study site is given by Scrimgeour & Winterbourn (1989).

METHODS

Five benthic samples were collected at monthly intervals from riffles between May 1985 and April 1986 using a 0.1 m^2 Surber sampler fitted with a 0.25 mm mesh net. Benthic samples were taken across the entire riffle section and therefore included most riffle microhabitats. Stream bed materials were agitated to a maximum depth of 10 cm and all invertebrates collected were preserved in 70% ethanol. Size frequency distributions of larval *A. colonica* were obtained by measuring a random, subsample of at least 40 larvae (maximum 130) from monthly benthic samples. When the total number of larvae taken in benthic samples was < 30 individuals (October to December) additional benthic samples were collected specifically to increase sample sizes for analysis of size frequency distributions. These samples were taken from the same riffle areas but were not used for density estimates. Larvae were measured with a linear eyepiece micrometer at 40x magnification. Larvae were dried to constant weight at 60°C, and weighed to the nearest 0.1 mg on a Mettler H52 pan balance to estimate benthic biomass.

Annual production was calculated using the Size Frequency (Hynes) method (Hamilton 1969, Benke 1979) assuming a cohort production interval of 1.0. The method assumes that an average size-frequency distribution obtained from samples taken over a year will approximate the mean survivorship of an hypothetical average cohort (Benke 1984).

RESULTS

DENSITY AND LIFE HISTORY

Mean density of larvae ranged from 30 to 2676 m^2 and varied significantly (single factor ANOVA $F = 173, P < 0.001$) throughout the 12 month study period. Density was highest in May-July (1292 to 2676 m^2) following a long, flood-free period (> 6 months, Fig. 1) and lowest in December following three large floods that ranged in size from 44 to 79 $m^{-3}s^{-1}$ (Fig. 2). Caddisfly densities increased rapidly during the December-February period when spates were absent.

Head capsule widths of *A. colonica* collected throughout the year formed four overlapping groups that represent instars (Fig. 3). Sukolski (1981) and Crosby (1975) found five overlapping groups with first instars ranging in head capsule widths of 0.16 to 0.20 mm (Sukolski 1981) 0.15 to 0.225 mm Crosby (1975). Thus, peaks in size frequency distributions are likely to represent instars II, III, IV, and V (Table 1).

A. colonica was univoltine in the Ashley

River and second instar larvae appeared in November and December when mean daily discharge ranged from 44-79 $m^{-3}s^{-1}$ and water temperatures were 16-18°C (Fig. 4). Larvae grew rapidly from December to April (summer) when water temperatures were high (14-22°C) and discharge was variable (7-88 $m^{-3}s^{-1}$). The increase in caddisfly density from December to February coincided with the numerical dominance of second and third instar larvae. Nevertheless, caddisfly populations consisted of a wide range of larval instars throughout the year and fifth instars and pupae were present in all monthly collections (Fig. 4). The presence of late instar *Aoteapsyche* larvae throughout the year was also observed by Towns (1981) in a small North Island stream.

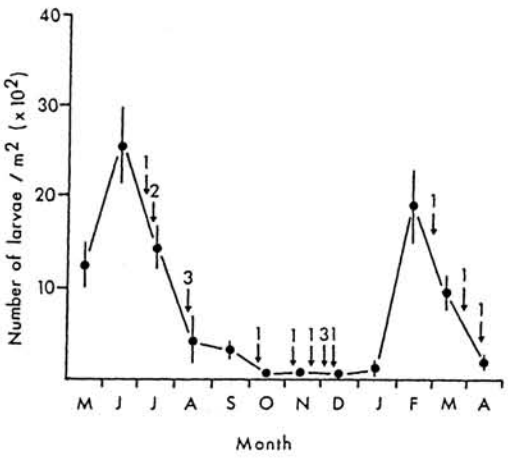

Figure 2. Mean density of *A. colonica* (± s.e.) in benthic samples from the Ashley River, 31 May 1985-13 April 1986. Arrows indicate occurrence and size of floods during the study period: 1, < 50 $m^{-3}s^{-1}$; 2, 50-90 $m^{-3}s^{-1}$; 3 > 90 $m^{-3}s^{-1}$.

ANNUAL PRODUCTION

Annual production of *A. colonica* was low (3.13 g DW m^2) (Table 2) despite the long period of low, stable flow prior to July 1985 when spate-mediated mortality would be low and when larvae may have aggregated within the reduced riffle areas. If annual production is recalculated with the high May-July densities excluded from calculations the annual production estimate (1.45 g DW m^2) is 2 times lower. Turnover ratios (P/B) ranged from 5.13 (all data: May 1985 to April 1986 to 5.77 (revised estimate: August 1985 to April

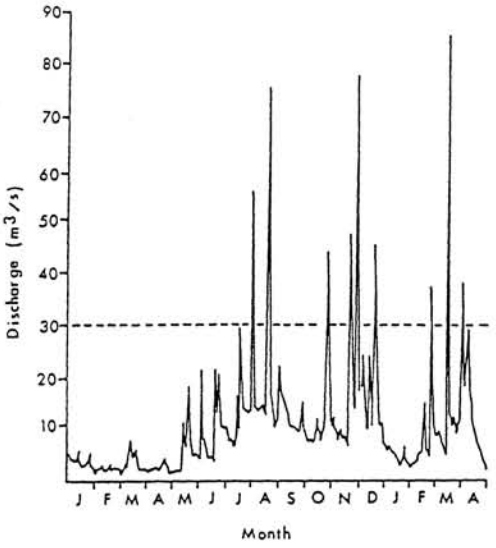

Figure 1. Mean daily discharge of the Ashley River at Ashley Gorge, January 1985-April 1986. The horizontal line shows the approximate discharge at which gravels and small cobbles are moved.

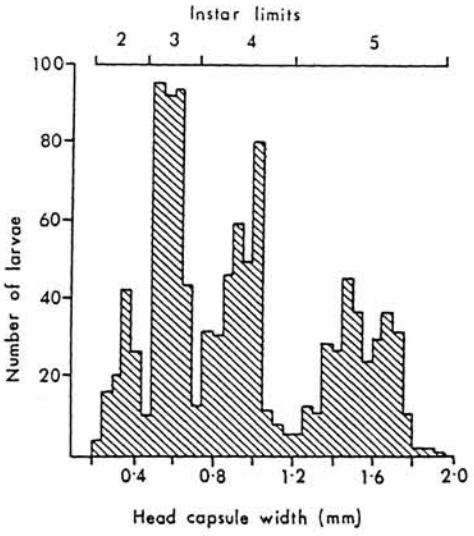

Figure 3. Size frequency distribution of all *A. colonica* larvae taken in benthic samples, Ashley River,31 May 1985-13 April 1986. Instar limits used in life history analyses are also shown. N=883.

Table 1. Instar description of *A. colonica* based on examination of head capsule widths and dry weights of individuals taken from benthic samples from the Ashley River, May 1985-April 1986. N is the number of larvae measured and weighed.

Instar	Mean head capsule width (mm)	Instar limit (mm)	Dry weight (mg)	N
I	-	< 0.23	-	-
II	0.38	0.23-0.48	0.13	80
III	0.62	0.50-0.70	0.19	256
IV	1.03	0.73-1.15	0.49	250
V	1.60	1.18-1.94	1.15	297

1986) and mean biomass ranged from 0.61 (May 1985 to April 1986) to 0.25 g m^{-2} (August 1985 to April 1986).

DISCUSSION

Annual production of *A. colonica* in the Ashley River is low (3.13 g DW m^2) but within the range of values reported for this species in New Zealand (Hopkins 1976) and for other hydropsychid caddisflies elsewhere (Waters 1977, Krueger & Martin 1980, Benke 1984, Benke *et al.* 1984, Jackson & Fisher 1986, Bowles & Allen 1991). Hopkins (1976) reported particularly low production estimates of *A. colonica* (0.96 and 1.32 g m^2) in shaded headwaters of the Hinau Stream, New Zealand. In contrast, production was at least an order of magnitude higher (12.67 and 15.64 g m^2) at two fourth order sites in the Horokiwi Stream, New Zealand where canopy cover was low. Mackay & Waters (1986) found that annual production of *Hydrophsyche slossonae* and *H. pettiti* in Valley Creek, Minnesota ranged from 0.9 to 40.0 g m^2 and 1.2 to 11.6 g m^2, respectively. Annual production of *Cheumatopsyche arizonensis* in an intermittent Sonoran desert stream was 1.51 g m^2 (Jackson and Fisher 1986), whereas annual production of individual hydropsychid species on snags (i.e., submerged wooden substrates) in blackwater rivers in South Carolina ranges from 0.019 to 21.03 g m^2 (Benke *et al.* 1984).

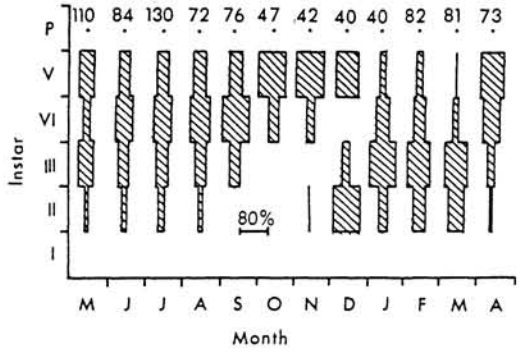

Figure 4. Instar composition of *A. colonica* taken in monthly benthic samples from the Ashley River, May 1985-April 1986. Sample sizes are shown. Asterix indicates the presence of pupae (P).

Lastly, production by hydropsychid caddisflies in an Ozark stream, Arkansas, ranged from 0.01 to 1.26 g m^2 (Bowles & Allen 1991). Thus, despite the occurrence of frequent, unpredictable spates, annual production of the hydropsychid *A. colonica* in the Ashley River is within values recorded from a variety of streams which differ in flow regime and physico-chemical parameters.

Interestingly, annual production was low despite the long period of stable flow during which mortality of larvae resulting from substrate movement is likely to have been minimal and larvae may have aggregated within the reduced riffle habitat areas (i.e., the wetted area). Thus, annual production calculated from May 1985-April 1986 (3.13 g m^2) may be higher than in most years when long periods of stable flow do not occur. In fact, the 173 day spate-free period represents the longest period of stable flow recorded in 13 years. When annual production was recalculated excluding the high larval densities observed during the May to July period,

Table 2. Calculation of secondary production of *A. colonica* from the Ashley River, May 1985-April 1986 using the Size Frequency (Hynes) method.

Size group limit	No. (m^2)	W (mg)	B (g/m^2)	ΔN	Weight at loss $\overline{W}$	Weight loss $\overline{W}\Delta N$	x 9 (g/m^2)
0.2-0.4	70	0.10	0.01				
				-107	0.13	-0.014	-0.126
0.4-0.6	177	0.15	0.03				
				21	0.20	0.004	0.036
0.6-0.8	156	0.25	0.04				
				16	0.32	0.005	0.045
0.8-1.0	140	0.38	0.05				
				47	0.50	0.024	0.216
1.0-1.2	93	0.61	0.06				
				44	0.81	0.036	0.324
1.2-1.4	49	1.00	0.05				
				-39	1.30	-0.051	-0.459
1.4-1.6	88	1.60	0.14				
				-1	2.00	-0.002	-0.018
1.6-1.8	89	2.40	0.21				
				84	3.10	0.260	2.340
1.8-2.0	5	3.80	0.02				
				5	3.80	0.019	0.171
			$B = 0.61\ g/m^2$				$P = 3.132$
			$P/B = 5.13$				

production was 2 times lower (1.45 g DW m^2). Hence, among-year variation in discharge regime may have a profound effect on production calculations and should be taken into account if comparisons are to be made among years or with other lotic systems.

Reduced invertebrate densities following flood events are the result of mortality and emigration through catastrophic drift. Indeed, riffle-dwelling invertebrates in rivers with frequent and extreme flow fluctuations may be constantly redistributing themselves from refugia occupied during floods (i.e., hyporheos, stream margins, instream debris, backwaters). Following flood events, macroinvertebrate larvae typically recolonize previously denuded riffle areas and some New Zealand taxa (leptophlebiid mayflies, chironomids, simuliids, elmids) are know to do this rapidly (Sagar 1983, 1986, Scrimgeour *et al.* 1988). However, studies of the colonization rates of *Aoteapsyche* larvae in baskets of natural substrates in the Rakaia River (Sagar 1983) and artificial substrates in a North Island river (Boothroyd & Dickie 1989) suggest *Aoteapysche* larvae are much slower colonizers. Moreover, *Aoteapsyche* populations did not recover to pre-flood densities in the Ashley River for 5 months following a particularly large flood in 1986, and the increase in numbers corresponded with the appearance of early instars and not immigration of later instars. Thus, recovery of *Aoteapsyche* populations in the Ashley River may be predominantly the result of oviposition rather than immigration of larvae from refugia (Scrimgeour *et al.* 1988, unpubl. data). Thus, the presence of fifth instar larvae and pupae of *A. colonica* throughout the year enables continual repopulation of denuded riffles through oviposition by continually emerging adults and likely contributes towards the persistence of *A. colonic*a in the Ashley River.

Lastly, the presence of caddisfly larvae and

other macroinvertebrates in the benthos of the Ashley River throughout the year provides a food source for predators. Glova *et al.* (1985) suggested that the higher riffle-welling fish densities observed in the Ashley than the more flood-prone Rakaia River was in part a consequence of differences in their flow regimes that enabled higher invertebrate densities and biomass to be maintained in the Ashley River. In fact, total invertebrate density in the Ashley River (Scrimgeour & Winterbourn 1989) was 2-10 times higher than that in the Rakaia (Sagar 1986). If differences in food availability explain differences in density of riffle-dwelling fish populations between these river systems, then secondary production in the Ashley River should exceed that in the Rakaia. My production estimates for *Aoteapsyche* (3.13 g m^2, this paper) and *Deleatidium* (4.51 g m^2: revised estimate, cf. Scrimgeour 1991) suggest that secondary production in the Ashley River is low and indicate that production in the Rakaia would have to be extremely low. Until secondary production in the Rakaia is calculated, the hypothesis that differences in food availability (i.e., secondary production) contribute to differences in secondary consumers in these systems will remain untested.

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